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TRENDS IN DRINK/DRIVING REVEALED BY RECENT ROAD ACCIDENT DATA

by J Broughton

Road Safety Division
Safety and Transportation Group
Transport and Road Research Laboratory
Crowthorne, Berkshire, RG11 6AU
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ABSTRACT

Long term trends in drink/driving are subjects of great public concern, yet they are difficult to analyse because of changes in procedures for identifying drivers with illegally high alcohol levels. The difficulty is overcome in this report by studying in particular accident trends for the part of the day when drink/driving is most common, namely 10 pm–4 am. The report concludes that the number of casualties in drink/drive accidents fell by approximately one half between 1979 and 1988.

The fall has been fairly regular since 1980, but with a sharp decline in 1983 when the law relating to drink/driving was changed and evidential breath-testing was introduced by the 1981 Transport Act. This Act also introduced compulsory seat belt wearing and new procedures for licensing learner motorcyclists. It is estimated that 490 fewer people were killed in the year after the Act took effect, and 36,000 fewer people were injured. The contributions of the individual measures are evaluated, which shows that some previous estimates of the casualty reductions were probably too low.

1 INTRODUCTION

The extent of drink/driving on British roads and the associated toll of road accidents continue to be topics of particular concern and public interest. A primary source of information is the database of Stats19 accident records maintained at TRRL. This report presents various analyses of these data from 1979 to 1988, which complement and extend earlier work (Broughton and Stark, 1986). That work studied in depth the changes that occurred in 1983: the present report concentrates on broader trends over an extended period, and provides more up-to-date information. In addition to studying trends in drink/driving accidents, it identifies general casualty trends, both for the whole population of road users and among particular groups of road users.

The analysis of trends in drink/driving accidents is constrained by a particular difficulty which applied to the earlier work: it is impossible to identify all drink/drive accidents from the records available. To overcome this, casualty trends in the hours of peak drink/driving, namely 10 pm–4 am, are compared with trends for the remainder of the day. The latter forms a control period, when any change in the extent of drink/driving is unlikely to affect the level of casualties significantly. Thus, any change in the ratio of the number of casualties between 10 pm and 4 am to the number between 4 am and 10 pm should indicate a change in the level of casualties suffered in drink/drive accidents. However, when the ratio changes over an extended period, other factors may also have had an influence, so only qualitative conclusions can be drawn: changes in the number of casualties in alcohol-related accidents cannot be established reliably in these cases.

As a secondary issue, the report reconsiders the effects on casualty totals of the 1981 Transport Act, the major piece of road safety legislation in the decade being studied. This was implemented early in 1983, and introduced compulsory seat belt wearing and new procedures for licensing learner motorcyclists. It also changed the law relating to drink/driving, most notably by introducing evidential breath-testing and increasing penalties.

Section 2 considers various technical questions relating to the analysis of the basic casualty data. Section 3 then establishes the trends of selected series of casualty data from 1979 to 1988, and section 4 studies the effects of the 1981 Transport Act. The conclusions are summarised in section 5.

This report is not an exhaustive review of sources of information relating to drink/drive accidents. Other aspects have been covered by Jones and Everest (1987), in particular the important evidence provided by Coroners and, in Scotland, Procurators Fiscal. Also, the Road Accidents Great Britain series provides relevant information annually (see, for example, Department of Transport, 1988a).

2 THE ANALYTICAL METHODS

Two particular aspects of the analysis of trends in drink/driving need especial attention. Section 2.1 considers the problem of studying trends in drink/drive accidents. Section 2.2 then describes a flexible method of modelling time series of casualty data which has been developed from a method used in previous studies.

2.1 TRENDS IN DRINK/DRIVE ACCIDENTS

The analysis of trends in drink/drive accidents is constrained by a particular difficulty which applied to the earlier study (Brougton and Stark, 1986): it is impossible to identify reliably all drink/drive accidents. The Stats19 record for an accident shows whether any of the drivers involved failed a roadside breath-test, but:

- many drivers who have been drinking are not breath-tested (operational policy varies between police forces and through time, and the percentage of accident-involved drivers who are breath-tested rose irregularly from 10 in 1979 to 19 in 1988),
- chemical breath-testing gives less reliable results then modern electronic methods; its use has diminished, but it is still used in some areas,
- if a breath-tested driver passes the test, there is no indication of his alcohol level-even if he was only just inside the legal limit, and his driving ability was already impaired by alcohol.

These factors together mean that trends in drink/drive casualties cannot be successfully examined simply by studying those accidents that yield a positive screening breath-test. Fortunately, a suitable surrogate exists for the proportion of accidents that are alcohol-related: the ratio of the number of accidents occurring during the peak hours for drink/driving, 10 pm–4 am, to the number occuring during the rest of the day. The statistical value of this surrogate can be shown by comparing its value, over a number of years and for groups of police forces, with the proportion of dead road users who had illegally high blood alcohol levels, as shown by Coroners' returns.

The analysis reveals a linear relation which explains about 60 per cent of the variance in the Coroners' data. The relation implies that when the ratio falls, the most reliable objective measure of the extent of drink/driving (the proportion of fatalities in Coroners' returns who died with illegal blood alcohol levels) will also fall. So, a change in the ratio indicates a change in the level of casualties suffered in drink/drive accidents, but the relation is too imprecise to estimate the change with any confidence.

When a similar analysis is performed with data from accidents involving a positive breath-test, no satisfactory linear model can be fitted—presumably for the reasons outlined above. This means that the relation between the number of drink/drive accidents and the number of accidents involving a positive breath-test is too complex to be represented adequately by a simple linear model. In the absence of a suitably sophisticated model of this relation, analysis of the ratio is the most satisfactory method available for monitoring the trend in drink/driving.

There may, of course, be alternative explanations for changes in the ratio, although in general only for gradual changes. For example, evolving patterns of social behaviour could alter the level of road travel in the late evening, which might affect the ratio independent of any change in the level of drink/driving. Alternatively, rising standards of vehicular and road lighting could tend to lower the ratio, since accident rates should be unaffected in daylight but lower in darkness. However, the strength of the linear relation just described does suggest that the level of drink/driving is the dominant influence.

The interpretation of a change in the ratio depends on whether it occurred rapidly (over at most three months), or gradually. With a rapid change, the altered number of casualties can be attributed entirely to a change in the level of drink/driving (unless, exceptionally, there is clear evidence of an equally rapid change in some explanatory factor unrelated to alcohol). Such a change occurred in May 1983, when new regulations were implemented to curb drink/driving, so it should be possible to estimate the casualty reduction brought about by this change. Where a change was gradual, however, other factors may also have had an effect (either positive or negative), and it would be unsafe to draw quantitative conclusions about the change in drink/drive accidents: only qualitative conclusions are possible in such a case.

Although the ratio is a successful surrogate for the proportion of accidents that are alcohol-related, it cannot be a perfect indicator: many accidents occurring between 10 pm and 4 am do not involve alcohol, whereas many accidents at other times do. However, the proportion of accidents which involve alcohol is undoubtedly much higher at this time of day. In 1987, for example, 13.7 per cent of drivers involved in accidents between 10 pm and 4 am failed a breath-test, compared with 1.4 per cent for the rest of the day (Department of Transport, 1988a). Hence, any change in the level of drink/driving should have little effect on casualty totals between 4 am and 10 pm, but a much larger effect on totals between 10 pm and 4 am.

Thus, the 4 am–10 pm period provides control data which indicate how trends might have developed in the 10 pm–4 am period *if* drink/driving had remained at its earlier level. This is the basis used in section 3 when drawing qualitative conclusions about the change in drink/drive casualties over several years.

Licensing regulations in England and Wales were liberalised in August 1988. This may have led to increased daytime drinking, so the validity of this approach will need to be checked in future. The present work should not be affected, however, as the change came so late in the decade being studied.

2.2 MODELLING CASUALTY TIME SERIES

The analyses reported below all examine monthly series of casualty data. The month is a convenient choice for the unit of time, but random fluctuations in the data still cause problems, especially when dealing with fatalities. For example, the number of car occupants killed in accidents on built-up roads in the months of 1986 were:

46 39 50 41 58 34 45 49 51 60
41 47

Are variations about the monthly average of 46.8 simply random effects, or do they reflect genuine changes? A consistent method is needed that will accommodate random fluctuations and yet reveal underlying trends in the data.

Broughton and Stark (1986) studied the effects of the 1981 Transport Act, relying on a model of the form:

$$C(t) = \exp\,(k + T.t + I.\sigma_I + r(t)) \qquad (1)$$

where C(t) is the number of casualties in month t (t = 1 for Jan 1979),
T is the underlying rate of change of the monthly casualty total,
I is the change that occurred about the time when the legislation took effect,
σ_I is a dummy variable that is zero for the period before the legislation took effect, and 1 afterwards,
r(t) is the residual term which measures the difference between the fitted model and the data,
k is a coefficient which varies with month of the year.

To calibrate the model, equation (1) is transformed:

$$\log(C(t)) = k + T.t + I.\sigma_I + r(t) \qquad (2)$$

This approach assumes that the dependent series log(C) rises or falls by a constant amount each month, once seasonal and legislative effects have been taken into account (ie the underlying trend is linear). The assumption can only be checked, with some difficulty, by examining the residuals r(t).

In retrospect, the approach suffers from various linked problems. Considering the changes that have occurred in recent years, the assumption that the trend has remained linear over several years appears unduly restrictive: the longer the period being studied, the less plausible it becomes. The approach is an awkward way of detecting changes in trend, and there is no clear indication of how to proceed when the assumption of linearity proves unacceptable. Accordingly, the model has been developed to accommodate a more flexible form of trend, which can be displayed graphically. The exact form chosen is the quadratic spline, which is introduced in Appendix A1. Appendix A2 then describes the new model and shows how it is used to analyse time series of casualty data.

The new model is directly comparable with (2), except that the linear trend (T.t) has been replaced by a more flexible form which is capable of following changes in the general level of casualties. This is achieved by incorporating extra variables: in place of the single variable t there are now two, with additional variables to represent changes in trend. There could be cases where the new trend is sufficiently nearly linear for no extra variable to be needed: appendix A3 explains how to check for this possibility and, more generally, how to identify the number of signifcant changes in trend.

The new model with its quadratic spline trend is simply a pragmatic development of an existing model for analysing time series of data. Various alternative forms of Time Series Model (TSM) exist, several developed from the work of Box and Jenkins (Box and Jenkins, 1970). These generally incorporate advanced statistical concepts, but often suffer from important practical disadvantages: they tend to be complex to use, relying on the experience of the analyst and his proprietory software for their success, and their results are often difficult to explain to those unfamiliar with the particular technique. Moreover, in the two examples known where an 'advanced TSM' and the simpler model (2) were applied in parallel to the analysis of road accident data, the two approaches yielded very similar results. (The two examples are a study by Scott (1986) of British accident data for 1970-78, and the evaluation of the effect of compulsory seat belt wearing (Department of Transport, 1985).) This suggests that time series of national casualty data are sufficiently regular for the theoretical advantages of these more advanced models not to be realised in practice. Doubtless this would not be true of many other applications.

It has been concluded from these considerations that the extra complexity of theoretically more advanced models is not justified in the present work, and that the model with the quadratic spline should provide adequate flexibility, while allowing results to be presented clearly.

3 RECENT CASUALTY TRENDS

This section examines general casualty trends over the period 1979-88 using the approach described above; the effects of the 1981 Transport Act will be analysed in section 4. The entire population of road users is considered first, followed by particular classes of road user. In all cases, three series of casualty data will be examined:

- monthly totals of road users killed,
- monthly totals of road users killed or seriously injured (KSI),
- monthly totals of road users injured (any severity).

The computed casualty trends for various road user groups will be presented in series of figures. In order to compare directly the changes in the trends shown in each figure, logarithmic scales are used. As explained in appendix A2, the statistical process which fits these curves concentrates on longer-term variations in trend. Nevertheless, a few curves do include short-term oscillations. These must have been found significant when fitting these curves, but minor oscillations can safely be ignored.

3.1 ALL ROAD USERS

Previous studies have shown differences between the casualty trends on rural and urban roads. Accordingly, casualties are examined first on built-up roads (with speed limits up to 40 mph), then on non-built-up roads (with speed limits over 40 mph).

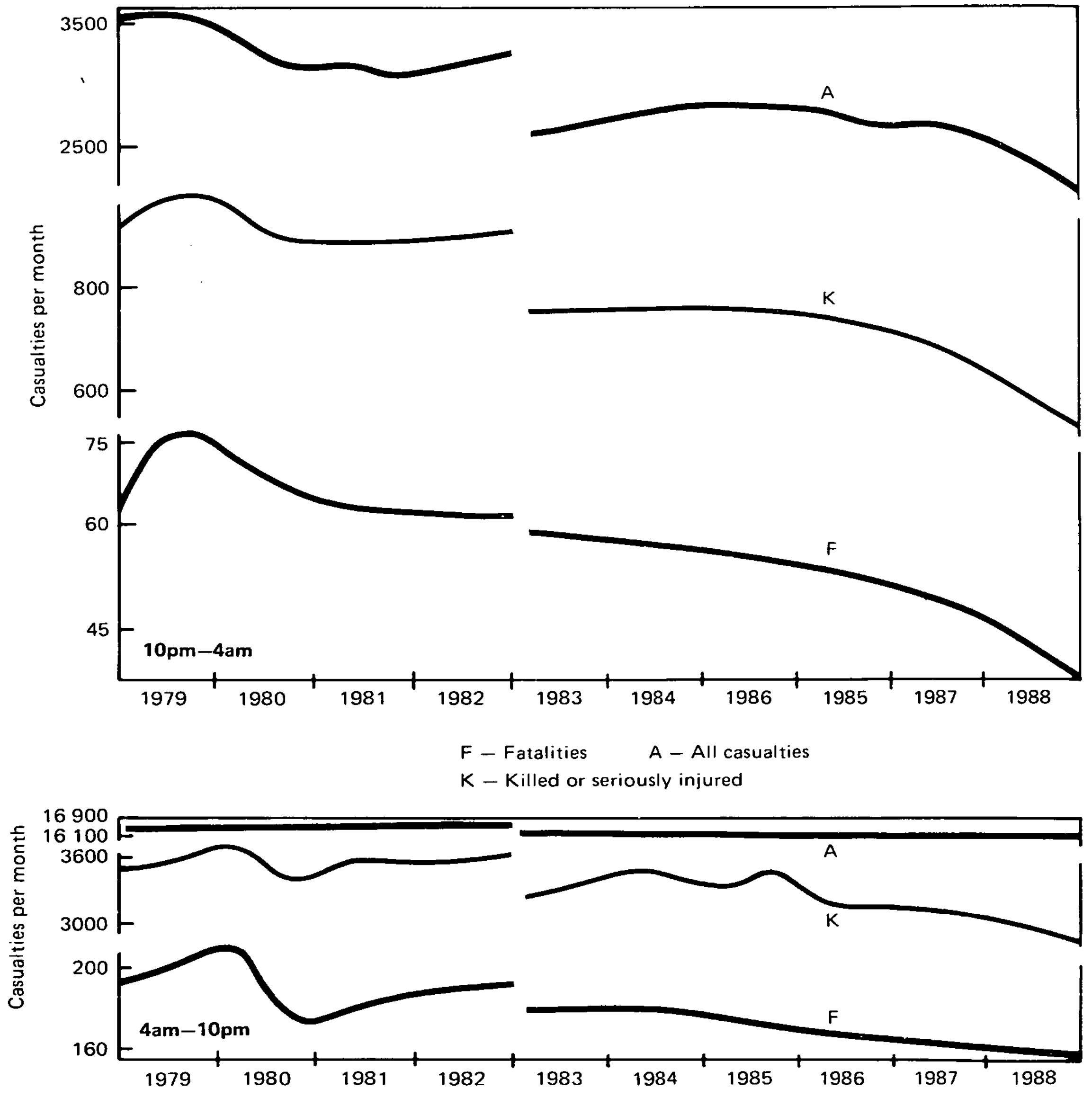
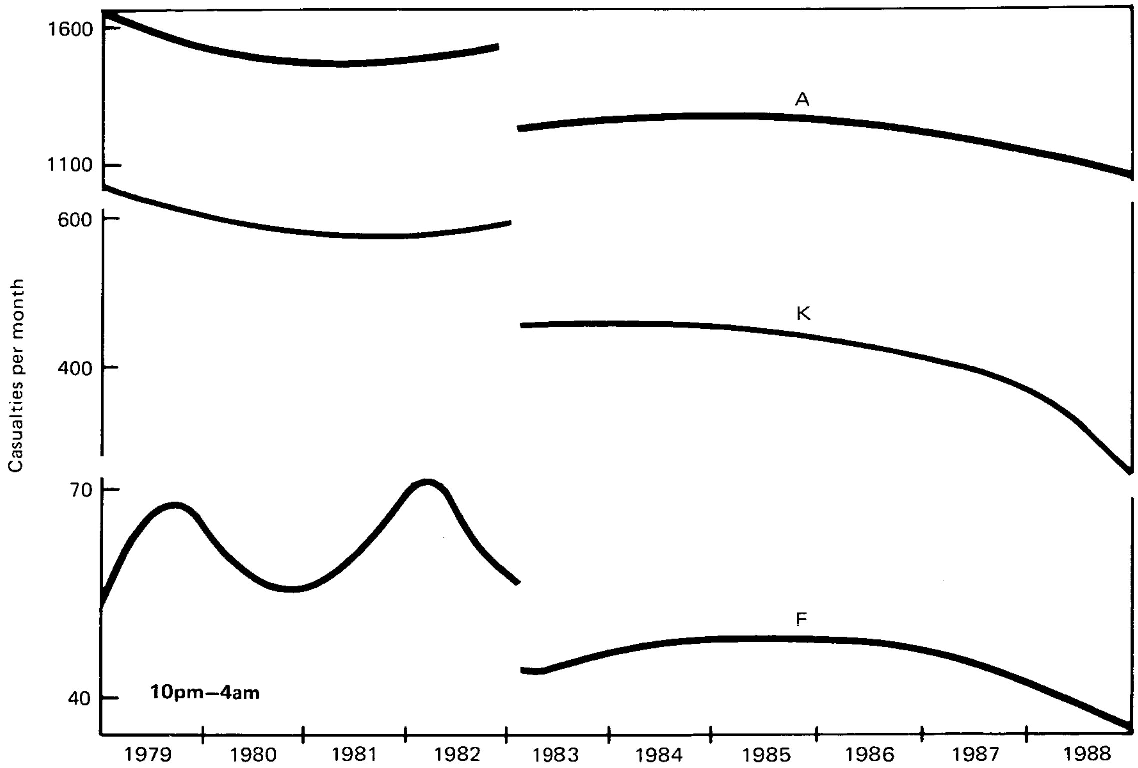


Fig. 1 Monthly trend in casualties, built-up roads

Figure 1 shows the trends for casualties on built-up roads for two periods: the 'drink/drive' hours from 10 pm to 4 am, and the rest of the day. Trends have generally fallen in the former period, although they did rise for non-fatal casualties in 1982-4. Trends for the latter period have been more stable, and have fallen for more severe casualties in recent years. In all cases, there were reductions early in 1983, presumably associated with the Transport Act.

Figure 2 shows the corresponding trends for non-built-up roads. There are some differences from figure 1, in particular for the 4 am—10 pm period. The trends for fatalities and for all casualties have generally risen since 1983, whereas on built-up roads they have fallen slightly.

Each graph in figures 1 and 2 is the quadratic spline which best represents the particular series of casualty data. None is exactly linear: in all cases the basic model (2) with its linear trend has been improved significantly by adding one or more terms. Thus, the use of the more complex model is justified, and the conclusions to be drawn may well differ to some extent from conclusions obtained in previous analyses that relied on the basic model.



F — Fatalities A — All casualties
K — Killed or seriously injured

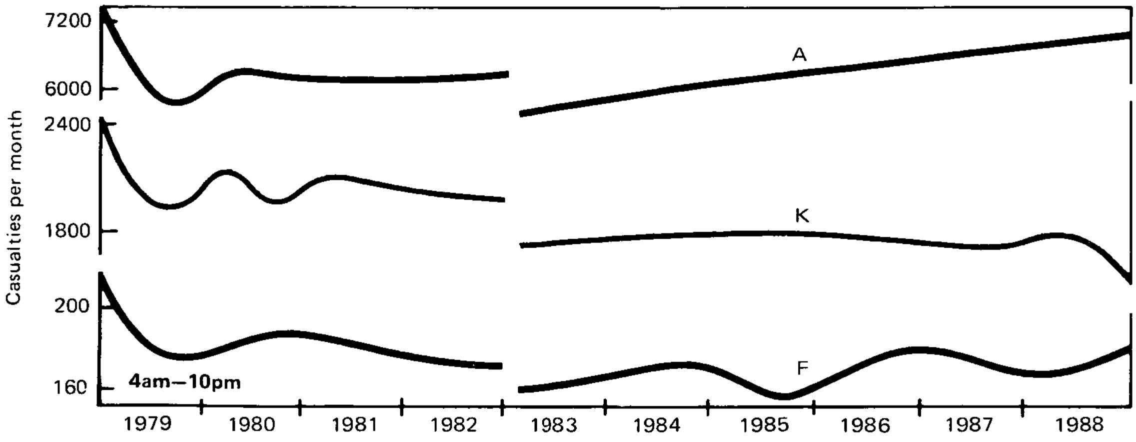


Fig. 2 Monthly trend in casualties, non-built-up roads

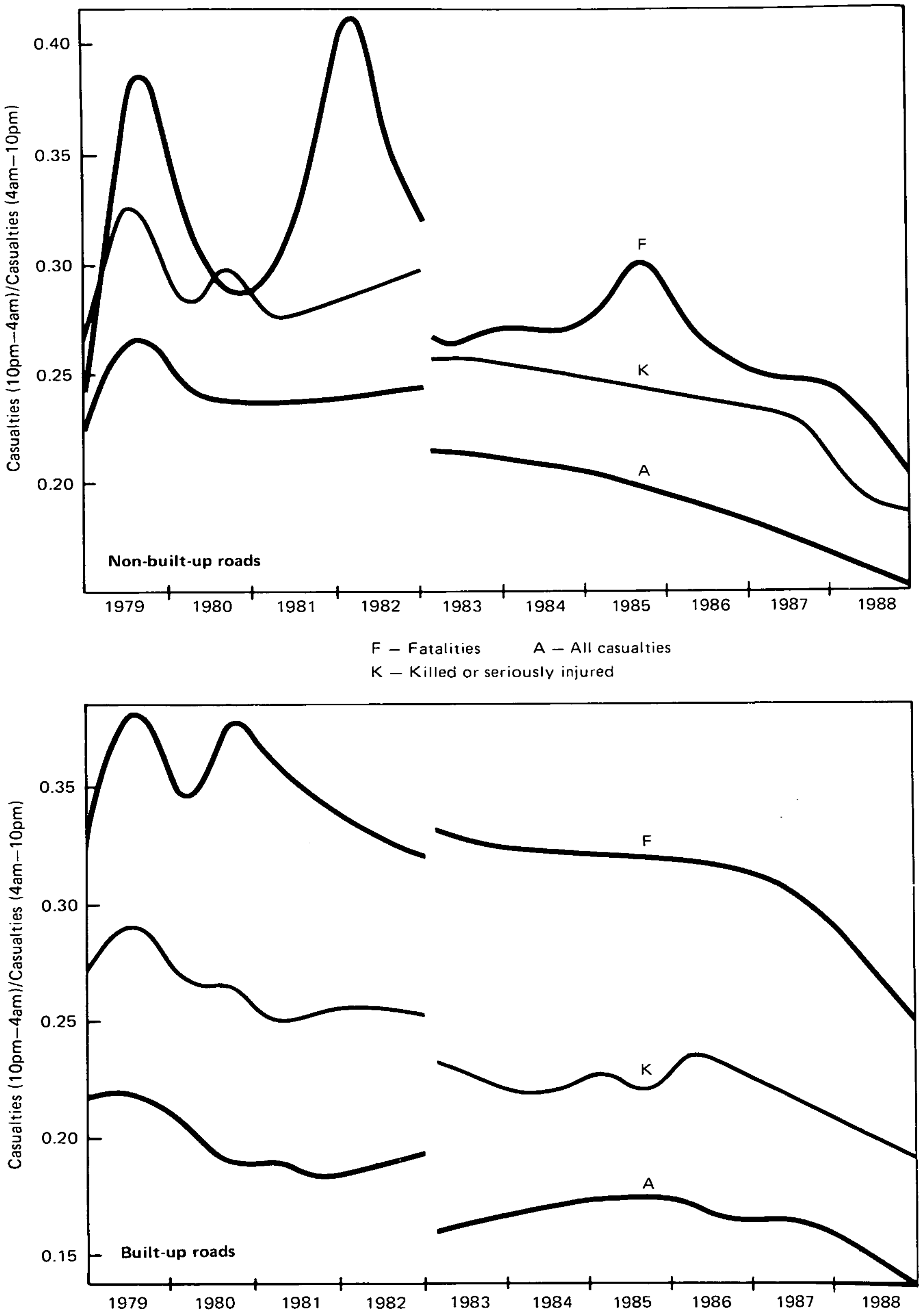


Fig. 3 Casualty quotients for all road users

The relationship between casualties during the drink/drive hours and the rest of the day is brought out more clearly in figure 3. This shows, for the six pairs of trends from figures 1 and 2, the quotient:

$$Q = \frac{\text{casualty trend during drink/drive hours}}{\text{casualty trend during rest of day}}$$

If conditions during the drink/drive hours had evolved more or less as they did during the rest of the day, Q would have stayed virtually constant over the years. In all cases, however, Q fell substantially between 1979 and 1988, but not uniformly. For example, in 1979 the number of fatalities on built-up roads during the drink/drive hours reached 38 per cent of the number for the rest of the day, but it fell to 25 per cent by the end of 1988. In fact, the casualty quotients for all six series had fallen by 1988 by more than one third form the peak values reached early in the decade.

All but one of the quotients fell considerably in early 1983, presumably associated with implementation of the 1981 Transport Act. It is also true, however, that Q has been falling for most of the casualty series through most of the decade, which probably indicates a progressive reduction in the number of casualties in drink/drive accidents. These falls predate the Act, and have continued long after, so they cannot be explained simply as delayed responses to the Act. Other influences must be present, such as the cumulative effects of successive campaigns of public information.

When Q falls, there are fewer casualties in the 10 pm—4 am period than there would have been if it had stayed constant. As an illustration, table 1 shows the reduction in the number of casualties in 1988 that resulted from the quotients falling between 1986 and 1988. This is the difference between the number of casualties that there would have been in 1988 if the quotients had remained at their 1986 levels, and the actual number in 1988:

$$\text{Reduction} = \frac{C2(1986)}{C1(1986)} \times C1(1988) - C2(1988)$$

where C1 refers to the number of casualties between 4 am and 10 pm and C2 to the number between 10 pm and 4 am. As discussed in section 2.1, it is likely that a large proportion of these reductions can be attributed to lower levels of drink/driving, but it is impossible to be more precise.

TABLE 1

Reduction in casualties in 1988 caused by the reduction in quotients between 1986 and 1988

	Fatalities	KSI	All casualties
Built-up roads			
Reduction in 1988	84	1140	3550
Reduction as percentage of actual number in 1988	16	16	12
Non-built-up roads			
Reduction in 1988	82	890	2320
Reduction as percentage of actual number in 1988	18	22	18

In addition to the difficulty of judging whether a change in Q is related solely to the level of drink/driving, another problem is to assess the likely minimum value of Q. If there were no drink/driving, people would still travel between 10 pm and 4 am and there would still be road accidents. Hence, Q will not fall to zero, no matter how successful are the efforts to eliminate drink/driving. The minimum value of Q cannot be established with any precision, but the National Travel Survey of 1985/6 (Department of Transport, 1988b) provides some guidance. It shows that over 6 per cent of car trips of less than 2 hours duration (which make up the great majority of car trips) start between 10 pm and 4 am: the percentage rises to almost 12 for young male drivers, a group which has a particularly high accident rate but is involved in relatively few drink/drive accidents (Broughton, 1990). This information is studied in appendix A4, where it is concluded that the minimum value of Q is probably at least 0.10 for all casualties, and that it may well be even higher for fatalities because of the greater average severity of accidents during the hours of darkness.

This suggests that very substantial reductions have been achieved since 1979 in the level of drink/driving: compared with the peak values seen early in the decade under study, the level of drink/drive casualties may well have fallen by over one half by the end of 1988. In the case of casualties on built-up roads, for example, the quotient fell from 0.22 in 1979 to 0.14 late in 1988. If, as appears likely, the quotient would fall to about 0.10 in the absence of drink/driving, this indicates a reduction in drink/drive casualties of up to two-thirds over the decade. Even if the minimum was only 0.06 (which seems unlikely), the reduction would still approach one half. The most recent trends indicate the likelihood of further reductions in future although, as discussed in appendix A2, the form of a trend may be less reliable over the first and last few months of the period studied.

The Stats19 breath-test data also show large reductions in drink/drive casualties although, as discussed in section 2.1, these probably underestimate the reductions in drink/drive casualties. The main reason is that drink/drive accidents are more likely to have been identified reliably at the end of the decade than at its beginning. In addition, these accidents cannot be identified from Stats19 data when the driver who had been drinking is killed, or so seriously injured that a breath-test cannot be carried out (although it may well be that these form a fairly constant proportion of all drink/drive accidents). On built-up roads, the proportion of deaths and casualties in known drink/drive accidents fell by 40 and 28 per cent between 1979 and 1988; the corresponding reductions on non-built-up roads are 37 and 25 per cent.

3.2 CAR OCCUPANTS

Monthly casualty trends for car occupants are shown in figures 4 (built-up roads) and 5 (non-built-up roads). On built-up roads, casualty trends between 4 am and 10 pm have generally risen, except for the abrupt falls in 1983; however, fatalities have fallen since 1985 and KSI since the beginning of 1988. Casualty trends between 10 pm and 4 am began to rise in 1981, but have fallen since 1985. The casualty quotients in figure 6 have tended to fall throughout the decade: the quotient for all casualties, for example, fell from two-fifths in 1979 to one fifth in 1988. The fatality quotient, by contrast, rose between 1983 and 1986, but has since fallen. Overall, it has fallen much less than the quotients for non-fatal casualties.

Recent trends on non-built-up roads (figure 5) have differed somewhat. For the 4 am—10 pm period, they have risen steadily since 1983, but for the 10 pm—4 am period they were stable for several years and have fallen since 1987. The quotients have fallen by up to one half from the peak values early in the decade; these falls have been broadly similar to those on built-up roads, except that the fatality quotient has fallen on non-built-up roads since 1982 (with one brief exception).

These results indicate that the number of car occupants injured in alcohol-related accidents has fallen steadily in recent years, and by perhaps one half over the decade; the exception to this is fatalities on built-up roads, which have fallen very little. The fall has been more rapid on non-built-up roads.

The pattern of these changes is repeated in the breath-test data. On built-up roads, the proportion of deaths that occurred in known drink/drive accidents rose by 3 per cent between 1979 and 1988, while the proportion of casualties fell by 32 per cent. On non-built-up roads, the proportion of deaths and casualties in these accidents fell by 23 and 30 per cent. There is no obvious reason why drink/drive fatalities on built-up roads have not followed a downward trend similar to that of the other casualty groups.

3.3 MOTORCYCLISTS

Figure 7 shows the monthly casualty trends for motorcyclists, which have been strongly influenced in recent years by the changing popularity of motorcycling. Both motorcycle mileage and the stock of registered motorcycles peaked about 1981, and the casualty trends follow the same general pattern. Figure 8 shows the casualty quotients that compare trends in the two parts of the day: they have declined regularly. For example, in 1979 the number of motorcyclist fatalities in the drink/drive hours reached almost one half of the number in the rest of the day, but it has since fallen to less than one fifth. There have also been progressive reductions among non-fatal casualties. This indicates that the number of motorcyclists injured in alcohol-related accidents has fallen markedly since 1979, probably by at least one half.

The proportion of motorcyclist deaths and casualties that occurred in known drink/drive accidents fell by 46 and 16 per cent between 1979 and 1988.

3.4 PEDESTRIANS

Figure 9 shows the monthly casualty trends for pedestrians. The non-fatal trends in the 4 am—10 pm period have fallen since 1984, following earlier oscillations, but the fatality trend may have turned up in 1987. The fatality trend in the 10 pm—4 am period has fallen continuously, but the non-fatal trends have oscillated since 1981. Consequently, the quotients for non-fatal casualties shown in figure 10 have varied within narrow ranges over the decade, while the fatality quotient has shown a small decline.

The casualty reductions revealed in the previous two sections must have resulted from a considerable fall in the level of drink/driving during the decade, so presumably the risk per pedestrian of injury in a drink/drive accident has also fallen. On the other hand, the pedestrian casualty quotients have been generally stable. This suggests that pedestrian activity has increased in the late evening, leaving more pedestrians exposed to risk. (Such an increase could be a consequence of success in curbing drink/driving, with many people choosing to walk rather than drive to social occasions likely to involve alcohol.)

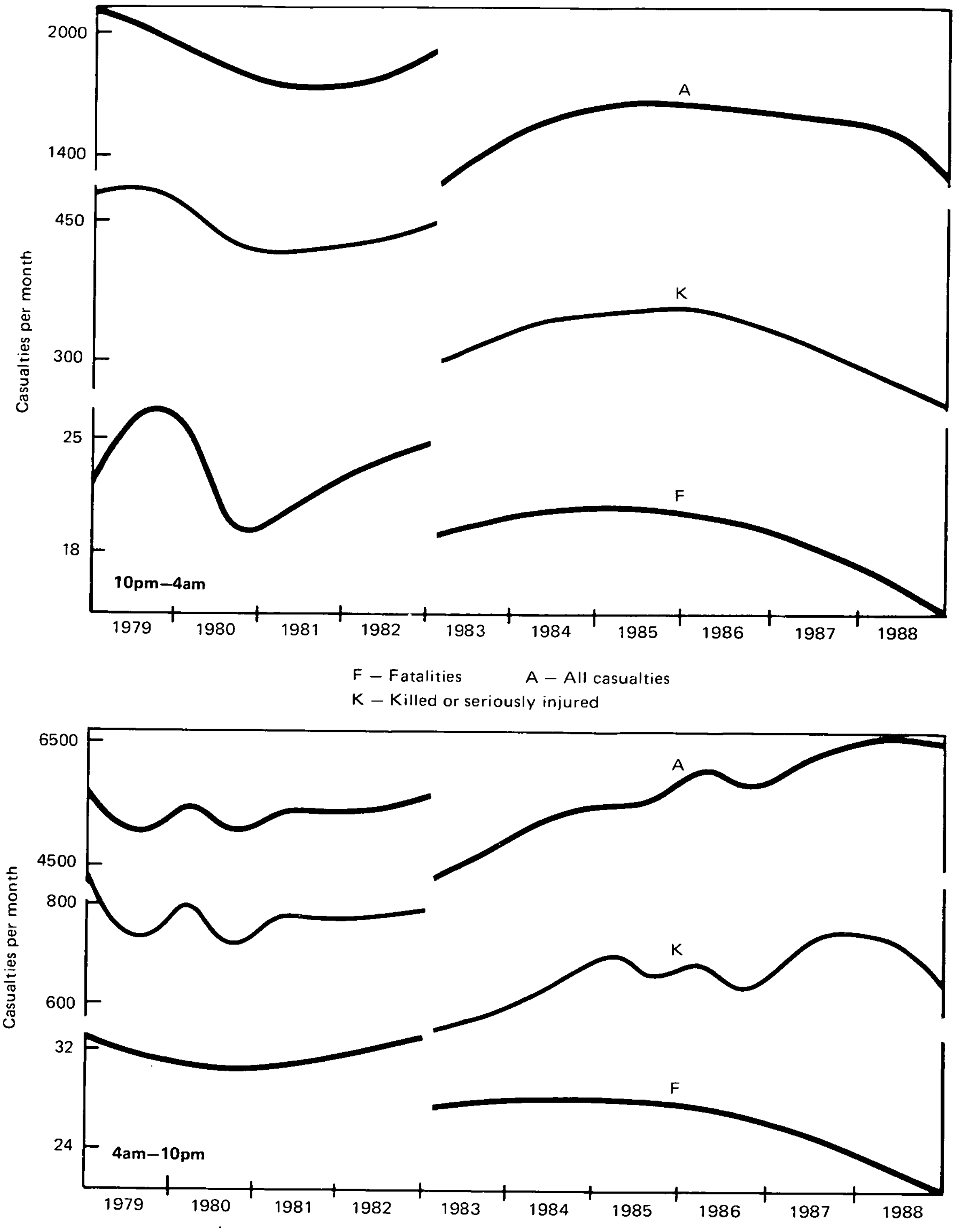


Fig. 4 Monthly trend in car occupant casualties, built-up roads

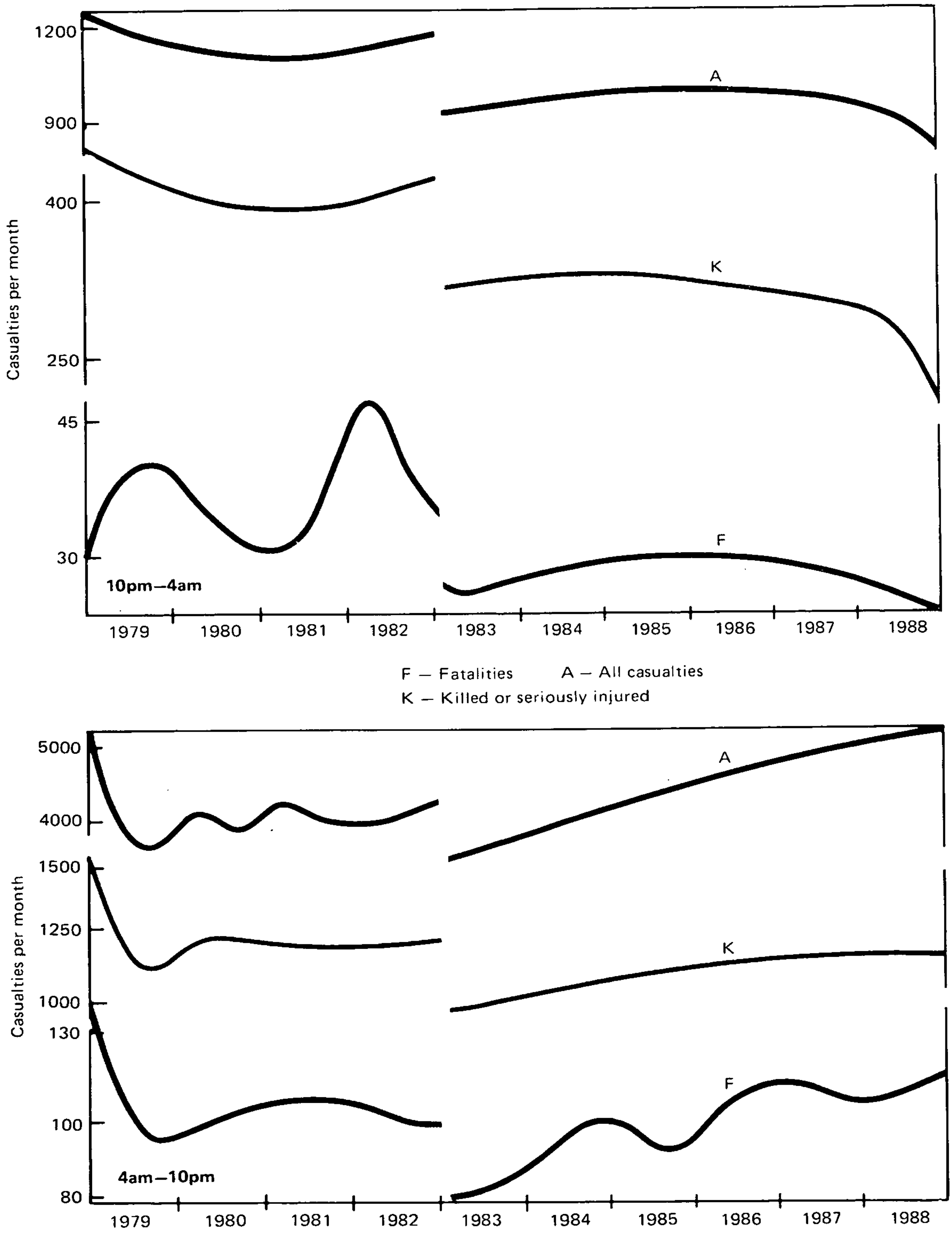


Fig. 5 Monthly trend in car occupant casualties, non-built-up roads

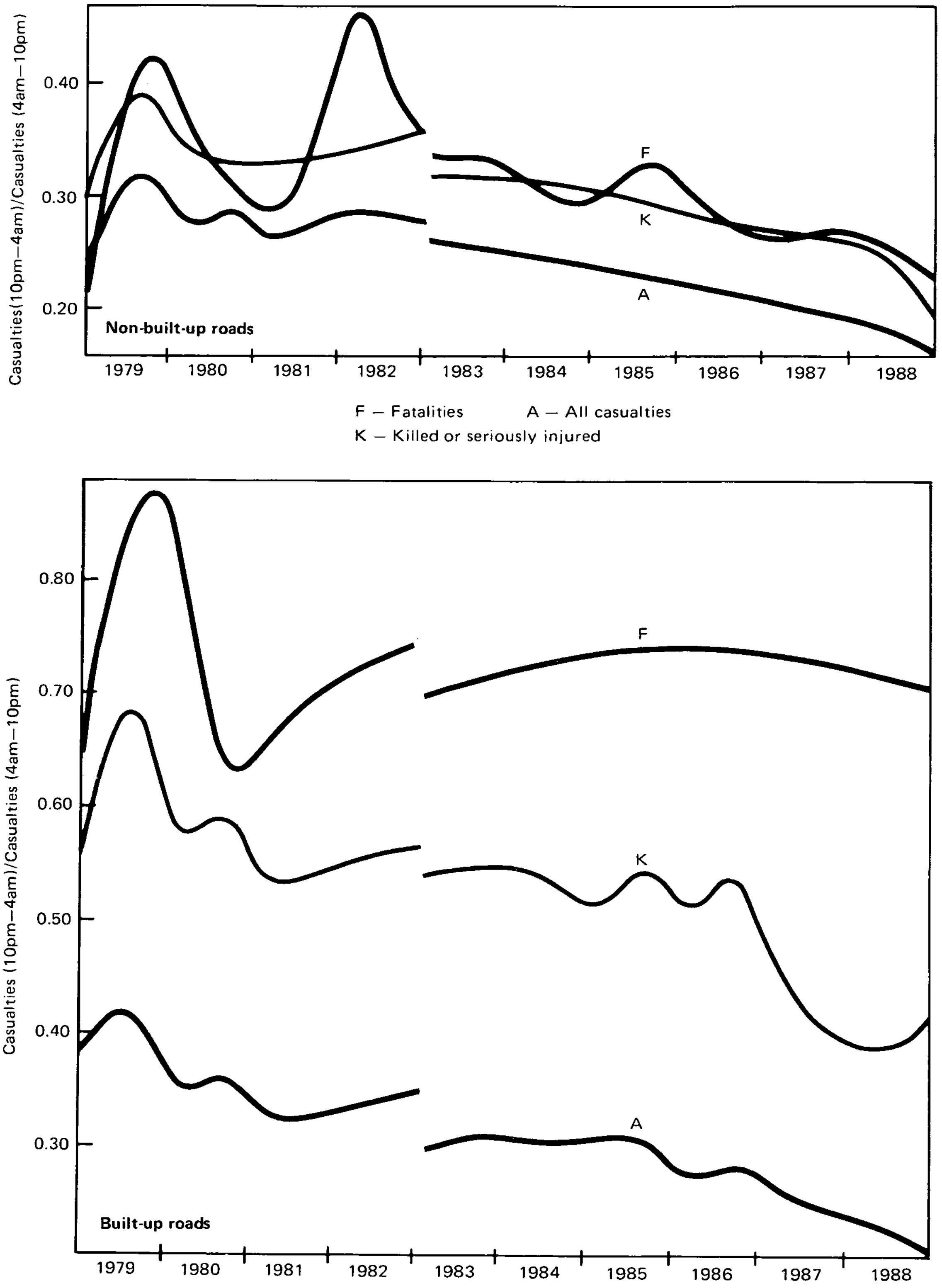


Fig. 6 Casualty quotients for car occupants

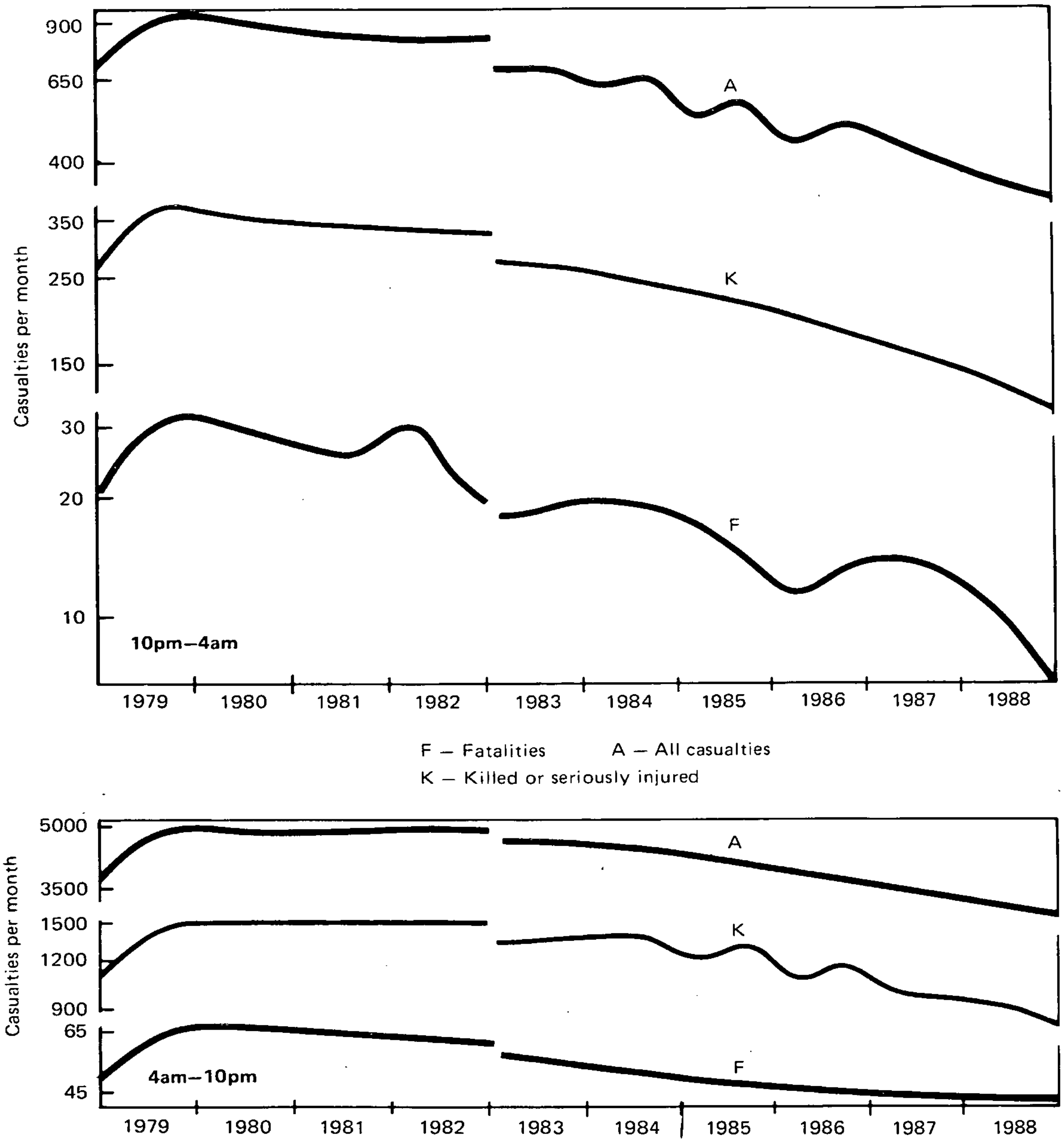


Fig. 7 Monthly trend in motorcyclist casualties

The Stats19 breath-test data are helpful here, although they must still be treated with caution. The number of pedestrians killed and injured in known drink/drive accidents fell by 64 and 40 per cent between 1979 and 1988: casualties in all accidents fell by only 17 and 12 per cent over the same period. As a result, the proportion of pedestrians killed in known drink/drive accidents has fallen by 57 per cent and the proportion injured by 32 per cent. This suggests that pedestrian casualties in drink/drive accidents have fallen in line with other groups, but that increased pedestrian activity in the late evening has led to more casualties in accidents where no driver had been drinking.

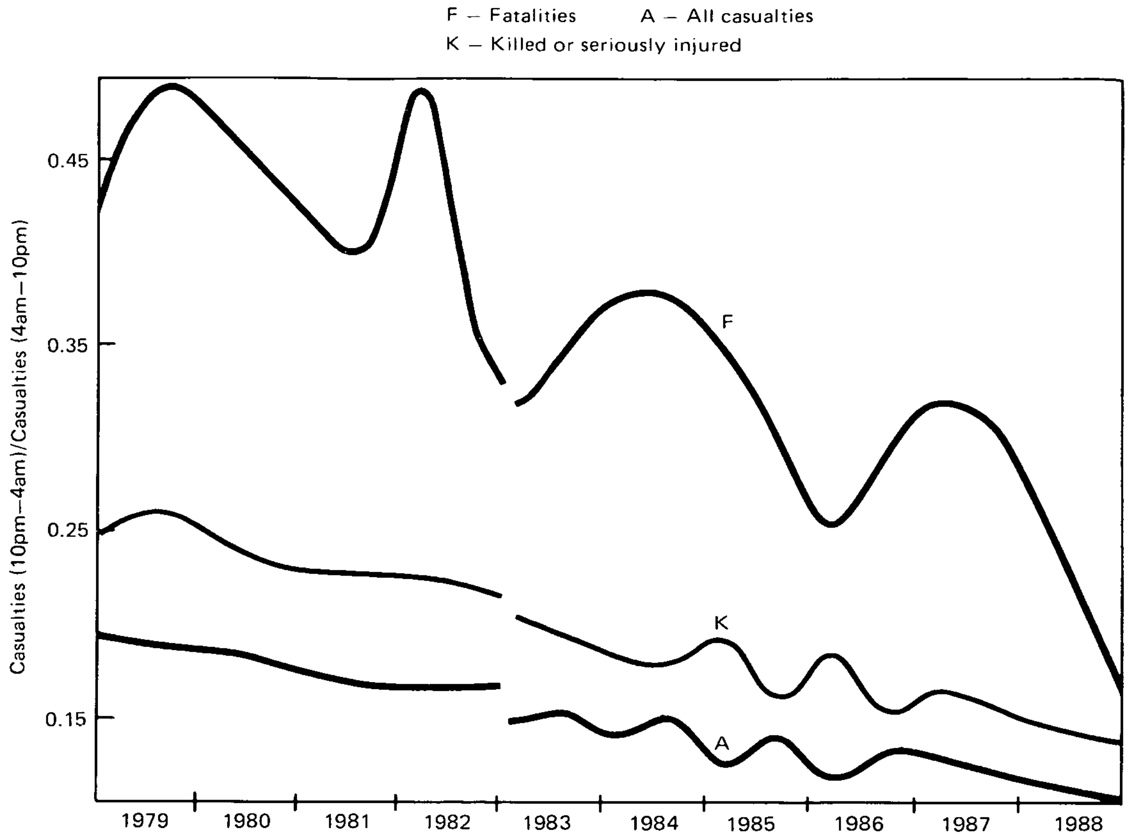


Fig. 8 Casualty quotients for motorcyclists

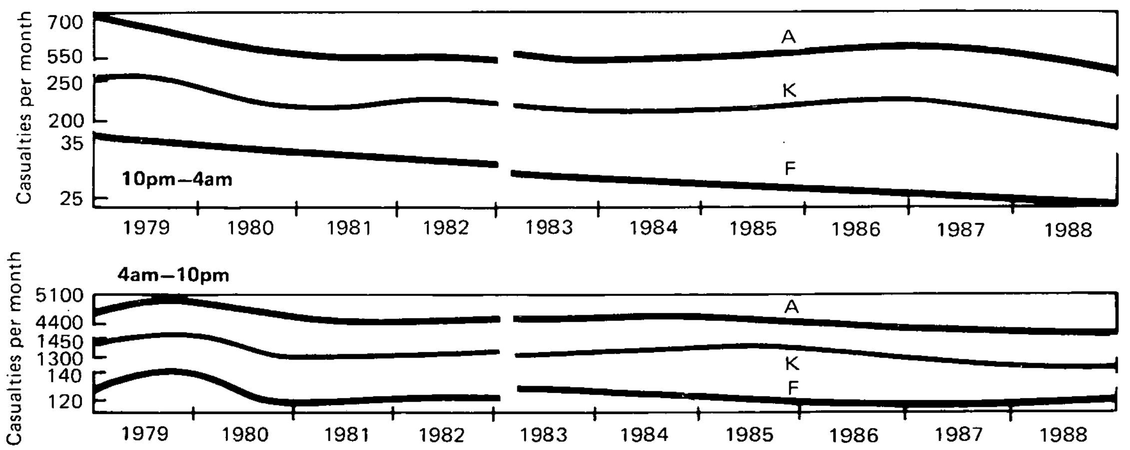


Fig. 9 Monthly trend in pedestrian casualties

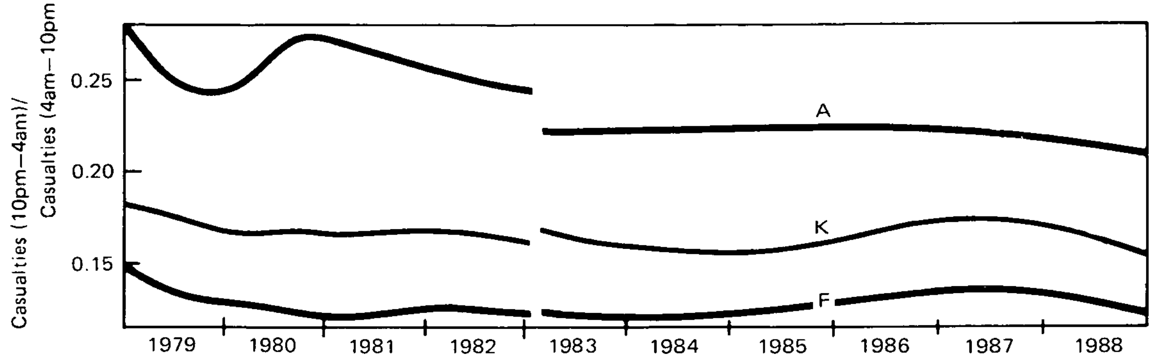


Fig. 10 Casualty quotients for pedestrians

3.5 MONTHLY VARIATIONS IN CASUALITIES

Each of the casualty series studied above follows an annual cycle, which is repeated in successive years. When casualties in, say, July are compared with the trend, the result is effectively the same for each year. These cycles are represented explicitly by the time series model, and are now considered.

For the model with linear trend (2), the level of casualties in the i-th month of the year, relative to the trend, is simply

$$\exp\ (\ k(i) - \bar{k}\ )$$

where k(i) is the value of coefficient k for month i and $\bar{k}$ is the mean of { k(i) }. The same is true for the model with the quadratic spline trend, and the transformed monthly coefficients from four pairs of series are shown in figure 11. Each series comprises casualties of all severities, and the relative monthly levels in the 10 pm—4 am period are compared directly with the levels in the 4 am—10 pm period. For each of the four graphs, 1.0 represents the average over the whole year, so values below 1.0 denote monthly totals below the annual average and values above 1.0 denote above-average totals.

The most pronounced variations occur with motorcyclist casualties, and in particular in the 10 pm—4 am period. Pedestrian casualties are relatively numerous from October to December, and car occupant casualties follow a similar pattern on built-up roads. On non-built-up roads, car occupant casualties are relatively few in the spring, but rise in July to a level which is maintained until December. Seasonal variations in the volume of travel clearly explain part of these variations.

The seasonal distributions of casualties revealed by these graphs are of interest. Unfortunately, they cannot be used to assess the relative frequency of drink/drive casualties at different times of the year, because the relation between casualty levels in the two parts of the day varies seasonally. One reason is the variation in the hours of daylight during the year: casualty rates (per kilometre travelled) tend to be higher in the hours of darkness, so will be higher for the 4 am–10 pm period in winter than in the summer, while the 10 pm–4 am period is scarcely affected. Figure 11 shows that there are indeed relatively many casualties in the 4 am–10 pm period in the winter, compared with the 10 pm–4 am period.

Related to this is the likelihood that evening travel, being largely discretionary, will be inhibited during the winter months by inclement weather. This is borne out by figure 11, where the divergence between the graphs is greatest for motorcyclists, the group most exposed to wintery conditions.

Only one conclusion related to drink/driving can be drawn from figure 11. Pedestrian casualties peak in December for the 10 pm–4 am period, while for the 4 am–10 pm period they are well below their November peak. This pattern occurs only with pedestrians, which suggests that the rise in pedestrian casualties in the late evening in the Christmas period is due to increased pedestrian activity in the late evening, rather than any seasonal increase in drink/driving.

4 THE EFFECTS OF THE 1981 TRANSPORT ACT

The 1981 Transport Act introduced three principal road safety measures:

(i) seat belt wearing was made compulsory for front seat occupants of cars and vans on 31 January 1983,

(ii) new drink/drive regulations took effect on 6 May 1983,

(iii) various amendments to licensing arrangements for learner motorcyclists were introduced between 29 March 1982 and 1 February 1983.

Measures (i) and (ii) took effect rapidly, as did the restriction of learner motorcyclists to machines of at most 125 cc capacity on 1 February 1983 (Broughton, 1987), one aspect of (iii). Appendix A2 describes how their effects are modelled, and they have already appeared as discontinuities in the casualty trends. Other aspects of (iii) will have had a progressive effect on casualties, contributing to the trends shown in figure 7.

The collective effects of these three measures can be determined directly. It is more difficult to determine their separate effects, because they were introduced over such a short period. Section 4.1 studies the effects of the new drink/drive regulations, by comparing the changes occurring between 10 pm and 4 am with those occurring between 4 am and 10 pm (as was done in previous sections). The effects on motorcyclist casualties of the capacity restriction are studied in section 4.2, and the results of compulsory seat belt wearing are then deduced. Sections 4.3 and 4.4 estimate the casualty changes among car occupants and pedestrians. Finally, section 4.5 considers the extent to which earlier conclusions about the 1981 Transport Act need to be revised.

4.1 ALL ROAD USERS

Table 2 shows the combined effects of the three measures that took effect early in 1983, both as percentage reductions and in terms of the casualties avoided in the first year. The reductions

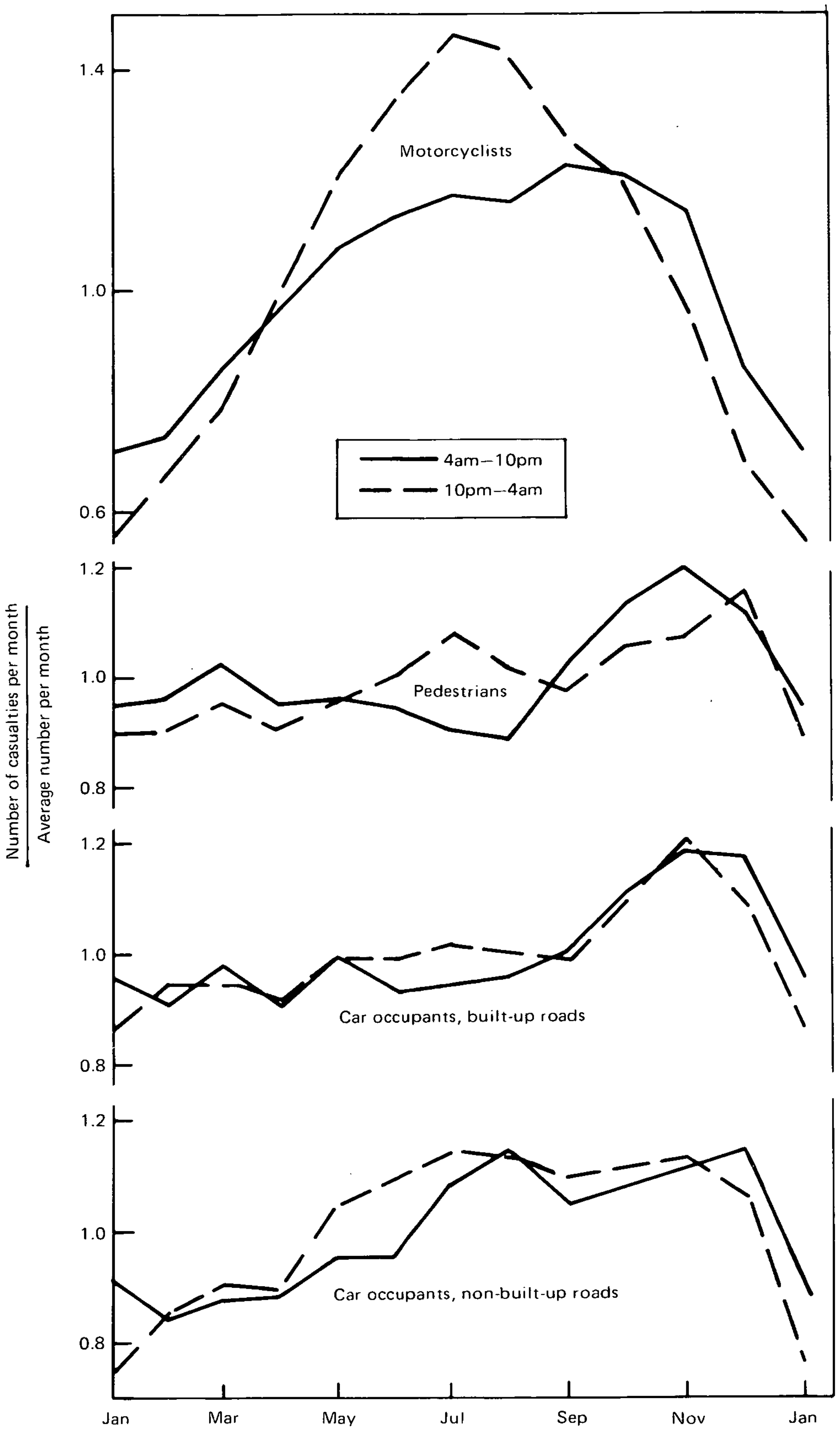


Fig. 11 Relative levels of casualties (all severities) by month

TABLE 2

Casualty reductions brought by the 1981 Transport Act

	Fatalities	KSI	All casualties
All roads, all day			
Reduction (%)	9	13	11
90% conf interval	3,14	8,17	6,15
Casualties avoided in first year	491	10900	35000
All roads, 4am–10pm			
Reduction (%)	8	10	9
90% conf interval	−2,18	6,15	4,13
Casualties avoided in first year	301	6960	24000
All roads, 10pm–4am			
Reduction (%)	12	24	22
90% conf interval	10,27	19,28	17,26
Casualties avoided in first year	206	4420	12600

shown are the best estimates for what actually occurred, but cannot be exact. Consequently, each percentage reduction is accompanied by its 90 per cent confidence interval to show the range within which one can, with 90 per cent confidence, be sure that the reduction actually lies. In cases where the interval does not include zero (ie both bounds are positive, or both are negative) then it is at least 95 per cent certain that a genuine change has occurred, rather than some random fluctuation in the casualty data. Such a change is described as 'statistically significant (at the 95 per cent level)'. (The reason for 95 per cent certainty in this case, rather than 90 per cent, is that if a change did occur then either it lay within the confidence interval (with 90 per cent probability), or it exceeded the upper bound (with 5 per cent probability), or it lay just below the lower bound: the sum of the three probabilities is at least 95 per cent.)

In the following tables, positive numbers indicate that the legislation brought about fewer casualties, and negative numbers indicate increased casualties. Each entry refers to the analysis of a single named data set. Where one data set is the sum of two or more others, the complexity of the modelling process may mean that the estimate of the casualties avoided differs from the sum of the individual estimates.

Table 2 shows greater percentage reductions for the late evening than for the rest of the day. This suggests that the new drink/drive regulations were effective, but the casualty savings can only be quantified if it is assumed that each of the other measures had equal effects in the two parts of the day. Evidence from Rutherford et al (1985), discussed by Broughton and Stark (1986), suggests that the increase in the seat belt wearing rate was similar at all times of the day. Moreover, there is nothing to show that a certain increase in wearing rate would reduce casualties more in the late evening than in the rest of the day. Thus, the assumption is reasonable in the case of compulsory seat belt wearing; for the new learner motorcyclist licensing arrangements, the assumption is plausible but not provable.

Table 3 shows the casualty reductions that can be attributed to the new drink/drive regulations. In this case, the calculation of the number of casualties avoided is based on the lower casualty levels that resulted from the earlier measures. The table shows that over one fifth of the reductions in non-fatal casualties in table 2 can be attributed to the drink/drive regulations, and that these reductions are statistically significant. The reduction in fatalities appears to have been less, and is not statistically significant.

The difference between tables 2 and 3 in the number of casualties avoided must be attributed to compulsory seat belt wearing and the capacity restriction for learner motorcyclists. The next section seeks to separate the effects.

TABLE 3

Casualty reductions brought about by the new drink/drive regulations

	Fatalities	KSI	All casualties
Reduction (%)	4	15	14
90% conf interval	−11,18	8,21	8,21
Casualties avoided in first year	65	2510	7590

4.2 MOTORCYCLISTS

Table 4 shows the reductions found early in 1983 among motorcyclist casualties. The table also estimates the reductions that may be attributed to the new drink/drive regulations, by comparing reductions in the two parts of the day. These reductions appear to have been less for the more severe casualties, and only the reduction for all casualties is significant. It is clear from the results for 4 am–10 pm that restricting learner motorcyclists to machines with engine capacity up to 125 cc led to casualty reductions which (except for fatalities) were significant.

Having estimated the combined effects of the three measures, and the seperate effects of two of the measures, the effect of compulsory seat belt wearing can now be calculated by direct subtraction. The results are brought together in table 5, with their 90 per cent confidence intervals in brackets. The intervals are inevitably wide for the individual measures, since uncertainty builds up with each step in the sequence of calculations. Nonetheless, the success of all three aspects of the legislation is beyond reasonable doubt.

The table estimates the casualty reductions achieved by each measure during the first year of its operation. Thus, casualty reductions from the seat belt and motorcycling changes are calculated for February 1983–January 1984, while casualty reductions from the drink/drive regulations and the combined measures are calculated for May 1983–April 1984. This slight inconsistency should not affect the comparison.

TABLE 4

Motorcyclist casualty reductions (all roads)

	Fatalities	KSI	All casualties
Casualty reductions, 4 am–10 pm			
Reduction (%)	6	12	11
90% conf interval	−7,21	6,18	2,12
Casualties avoided in first year	42	2290	4010
Casualty reductions, 10 pm–4 am			
Reduction (%)	7	16	17
90% conf interval	−11,29	8,24	8,26
Casualties avoided in first year	18	650	1830
Drink/drive casualty reductions			
Reduction (%)	1	4	11
90% conf interval	−47,33	−8,15	0,22
Casualties avoided in first year	3	160	1120

TABLE 5

The contribution of the separate measures of the 1981 Transport Act to its overall effect

	Fatalities	KSI	All casualties
Casualty reductions from:			
combined measures	491	11400	36400
	(155,810)	(8830,13800)	(25400,46600)
new drink/drive regulations	65	2510	7590
	(−170,280)	(1560,3390)	(4590,10400)
new regulations for learner motorcyclists	54	2760	4690
	(−40,145)	(1600,3780)	(1870,7280)
compulsory seat belt wearing	372	6120	24100
	(−45,755)	(2750,9260)	(10700,36700)

TABLE 6

Car occupant casualty reductions

	Fatalities	KSI	All casualties
All roads, all day			
Reduction (%)	25	30	21
90% conf interval	19,31	23,35	15,27
Casualties avoided in first year	595	10500	32300
Built-up roads, 4 am–10 pm			
Reduction (%)	20	30	22
90% conf interval	3,35	23,36	14,29
Built-up roads, 4 am–10 pm			
Reduction (%)	24	33	33
90% conf interval	3,40	26,39	27,39
Non-built-up roads, 4 am–10 pm			
Reduction (%)	19	19	17
90% conf interval	7,29	13,25	10,23
Non-built-up roads, 10 pm–4 am			
Reduction (%)	21	29	22
90% conf interval	–4,39	21,35	16,28
Drink/drive casualties			
Built-up roads			
Reduction (%)	5	5	14
90% conf interval	–30,30	–8,17	2,24
Non-built-up roads			
Reduction (%)	2	11	6
90% conf interval	–32,28	0,22	2,13

4.3 CAR OCCUPANTS

Table 6 shows the casualty reductions in early 1983 among car occupants, treating built-up and non-built-up roads separately. The effects are greater on built-up roads, perhaps because seat belt wearing rates had previously been relatively low on these roads. In contrast, it appears that the drink/drive regulations had broadly similar effects on both types of roads. Both reductions for all casualties and one KSI reduction are significant, but it is much less certain that the regulations reduced the number of fatalities.

It should be noted that the fatality reduction estimated for the aggregate series exceeds all of the estimates for the disaggregate series. This suggests that the reduction has been overestimated slightly, and that the number of car occupant fatalities avoided was actually about 500. Comparison of the casualty reductions in the two parts of the day suggests that the new drink/drive regulations reduced car occupant casualties in the first year by about 50 fatalities, 2000 KSI and 7000 casualties of all severities.

4.4 PEDESTRIANS

The change in pedestrian casualties in early 1983 is shown in table 7. The particular interest here is to evaluate the claim made at the time that car drivers would tend to drive more recklessly when wearing seat belts (the 'risk compensation hypothesis') and that vulnerable road users such as pedestrians would suffer in consequence.

The table gives no clear evidence of any change in pedestrian casualties; none of the changes approaches significance at the 95 per cent level, and there are as many apparent increases as there are apparent decreases. The change that approaches significance most nearly is the daytime reduction in KSI, but against this must be set the daytime increase in fatalities. One may conclude that none of the new measures affected pedestrian casualties.

4.5 DISCUSSION

Three studies of particular aspects of the 1981 Transport Act have relied on the linear model (2)

TABLE 7

Pedestrian casualty reductions (all roads)

	Fatalities	KSI	All casualties
All casualties			
4am–10 pm			
Reduction (%)	−5	3	0
90% conf interval	−15,3	−1,7	−4,4
Casualties avoided in first year	−82	540	85
10 pm–4am			
Reduction (%)	4	−1	−3
90% conf interval	−9,15	−12,8	−10,5
Casualties avoided in first year	13	−40	−165
Drink/drive casualty			
Reduction (%)	9	−5	−3
90% conf interval	−6,22	−17,6	−12,6
Casualties avoided in first year	30	−120	−175

to quantify the casualty changes that occurred in 1983. This section considers the possibility that their findings may need revision in the light of the new results. Only a general evaluation is made, as several of the casualty classes used in the earlier studies do not match those used in this report.

Compulsory seat belt wearing will be considered first, as studied in the 'Report by the Department of Transport' (1985). In section 2.3, the overall casualty reductions in the first year for front seat occupants of cars and vans were estimated as 470 fatalities, 7000 KSI and 13000 slight casualties, but no allowance was made for the effects of the new drink/drive regulations. These figures are somewhat less than the estimates in table 6 of the combined effect of the two measures on car occupant casualties, but the exclusion of van occupants and the inclusion of rear seat occupants in this table might account for a small part of the discrepancy. It is now clear that the great majority of these casualty reductions were due to compulsory seat belt wearing, although the new drink/drive regulations also contributed.

One important matter that has been clarified concerns the effect of compulsory seat belt wearing on pedestrian casualties. Increases in pedestrian casualties of 4–7 per cent were quoted in the Report, which were found to be statistically significant for non-fatal casualties. It now appears that these analyses were confounded by the non-linear trends shown in figure 9; there was no significant increase in pedestrian casualties in early-1983. There is some indication of a fatality increase, but this is offset by an equivalent indication of a reduction in KSI. It is difficult to see how changed driver behaviour brought by compulsory seat belt wearing could have led to more fatalities at the same time as fewer serious casualties. So, it may reasonably be concluded that these apparent changes resulted from random fluctuations in the casualty data.

The study of the drink/drive regulations appeared next (Broughton and Stark, 1986). It concluded that the regulations had been beneficial, using the approach followed in this report, but the benefits now appear to have been significantly underestimated. Contradictory effects were found among car occupants on built-up roads, and it was concluded that 'little evidence has been found of casualty reductions following the legislation' for this group. Table 6, by contrast, shows significantly casualty reductions on built-up roads, so the earlier conclusion must be revised. Further, the casualty reductions on non-built-up roads appear to have been underestimated. The casualty reduction reported among motorcyclists at least 25 years old is now seen to have applied to motorcyclists of all ages.

The final study was of the effects of the changed motorcyclist licensing procedures (Broughton, 1987). It was estimated, using the linear model, that restricting learner riders to machines of up to 125 cc engine capacity had reduced casualties by 7000, including 2430 KSI. However, as with the seat belt study, the new drink/drive regulations were not taken into account. From table 4, the comparable figures from the present work (ie for the whole day, including the effects of the drink/drive regulations) are 5840 and 2940, so in this case the linear model has provided reasonably reliable casualty reduction estimates. It can now be seen that part of these reductions were attributable to the drink/drive regulations, but even so the reduction in KSI that is attributed in table 5 to the new licensing procedures slightly exceeds the earlier estimate.

In summary, the results obtained with the more flexible time series model have provided a clearer impression of the effects of the 1981 Transport Act. The claims ofthe 'risk compensation hypothesis' that pedestrian casualties would increase as a result of compulsory seat belt wearing can now be discounted. Otherwise, the only previous result to need substantial revision is the extent of the benefit from the drink/drive regulations, which had been underestimated.

5 CONCLUSIONS

The analysis of trends in drink/drive accidents is complicated by the impossibility of identifying all of these accidents from police reports. Reliance on reports of known drink/drive accidents runs the risk that changes in police procedure will mask actual changes in the incidence of drink/drive accidents. A satisfactory surrogate is the ratio of the number of casualties during the 'drink/drive' hours between 10 pm and 4 am to the number during the rest of the day. Under certain conditions, changes in this ratio can be interpreted numerically in terms of casualties in drink/drive accidents, but otherwise only qualitative conclusions may be drawn.

The analyses have been carried out using a flexible statistical technique which has been developed to identify changes in long-term casualty trends. These trends then emerge clearly, freed from the short-term fluctuations that can make conventional graphs of casualty time series difficult to interpret.

The report has shown that casualty totals on built-up roads have tended to fall since 1980. The falls have been more rapid for the 10 pm–4 am period, indicating considerable reductions among drink/drive casualties. The position is more complex for non-built-up roads, with a steady increase since 1984 in slight casualties during the 4 am–10 pm period, but again the number of drink/drive casualties appears to have fallen substantially. It is impossible to be precise, but the number of casualties in drink/drive accidents may well have fallen by one half between 1979 and 1988. Recent trends indicate the likelihood of further falls in future.

The same comparative technique has shown progressive reductions in drink/drive casualties among car occupants and motorcyclists. In the case of pedestrians, casualties in drink/drive accidents appear to have fallen significantly, but casualties from all accidents have generally fallen no faster in the late evening than in the rest of the day. A likely explanation is that pedestrian activity has increased in the late evening (perhaps as a result of success in reducing the number of drinking drivers) which has left more pedestrians exposed to the risk of accidents.

The most important piece of road safety legislation to take effect between 1979 and 1988 was the 1981 Transport Act, which introduced various measures early in 1983. The Act's effects have been re-evaluated as part of the study of casualty trends, and they were found to be considerable. There were about 490 fewer deaths in the first year, with 11,400 fewer people killed or seriously injured and 36,000 fewer people injured. The effectiveness of compulsory seat belt wearing was confirmed (first year casualty reductions of 370/6100/24,000 respectively), but this result should be more reliable than earlier estimates because account has now been taken of the drink/drive regulations introduced by the Act. The effects of the new legislation (casualty reductions of 65/2500/7600 respectively) are now seen to have been seriously under-estimated by a previous study. The restriction of learner motorcyclists to machines with engine capacity up to 125 cc—one aspect of the new motorcycle licensing procedures—reduced casualties in the first year by 4700, 2750 of whom would have been killed or seriously injured. There may also have been a reduction in fatalities of about 50, although the evidence for this is less conclusive.

In the case of pedestrians, earlier studies had found casualty increases at the time when the new legislation took effect, but it now appears that there were no such increases. The earlier studies were misled by varying trends over several years, which must have been independent of the new legislation (this possibility was recognised in the original report (Department of Transport, 1985)).

6 ACKNOWLEDGEMENTS

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APPENDIX A

The general definition of the quadratic spline is given in Appendix A1, as it is a relatively unfamiliar mathematical function. It possesses certain attractive features, which are outlined. The particular application of the quadratic spline is described in Appendix A2, which also describes the method of fitting the model to a time series. Appendix A3 reviews the measure of 'goodness of fit' that is used to choose the optimal quadratic spline in each application.

A.1 THE QUADRATIC SPLINE

Let the quadratic spline f be defined over an interval that is made up of contiguous sub-intervals

$$[t_0,t_1]\ ,\ [t_1,t_2]\ .\ .\ .\ [t_{n-2},t_{n-1}]\ ,\ [t_{n-1},t_n]$$

The points t_1, $t_2 \ldots t_{n-1}$ are referred to as knots, as the quadratic spline consists of a series of quadratic polynominals, each defined over one sub-interval and 'tied' at either end to its neighbours. Specifically, f and its first derivative are required to be continuous at each knot. Higher order splines can also be defined, but the quadratic spline should be sufficiently flexible for the present application.

It can be shown that the continuity conditions imply that

$$f(t) = f_1(t) + \sum_{r=1}^{i} d_r.(t-t_r)^2 \quad \text{for } t_i<t<t_{i+1} \qquad (3)$$

where f_1 is a quadratic polynomial:

$$f_1(t) = a_1 + b_1.t + c_1.t^2 \qquad (4)$$

Thus, the quadratic spline can be viewed as a quadratic with the addition of an extra quadratic term following each knot. It is a linear sum of powers of t and so can be fitted as a linear regression model. Its great advantage lies in its flexibility; depending on the number and position of the knots specified, it can faithfully represent a very wide range of continuous functions. Moreover, as there are no exponents greater than two, it is more stable than a polynomial with an equivalent number of terms.

A.2 THE SPECIFIC MODEL

Three issues must be considered when developing the full model for time series of casualty data: seasonal variation, the choice of knots and the likelihood that casualty series will have been affected by the implementation of the 1981 Transport Act.

The time series are most conveniently analysed by month. To represent the seasonal variation, the constant a_1 in (4) is replaced by twelve constants, one per month.

The 1981 Transport Act introduced three measures which are likely to have had clear cut effects on monthly casualty totals. These were outlined in section 4, and took effect on 31 January/1 February 1983 (referred to as t') and 6 May 1983 (referred to as t''). The effect of these measures is introduced via two extra terms, a' and a'', so the extended model is:

$$\begin{aligned} f'(t) &= f\ (t) && t<t' \\ &= f\ (t) + a' && t'<t<t'' \\ &= f\ (t) + a'' && t<t'' \end{aligned} \qquad (5)$$

Thus a' should measure the combined effect of compulsory seat belt wearing and the motorcycle engine restriction, while a'' should measure the effect of the combined measures. This suggests that a'' − a' should measure the effect of the new drink/drive regulations, but in practice the shortness of the interval between t' and t'' makes this approach unreliable.

This extended model can still be fitted as a linear regression model.

In specifying knots, a compromise must be struck between having too many and too few. If too many knots are specified (as judged by the criterion to be defined in the next section) the model will be sub-optimal in the statistical sense: certain knots could be deleted without reducing the model's power significantly. Also, the long-term trend tends to be obscured when an excessive number of knots introduces short-term fluctuations into the trend. On the other hand, it may be impossible to detect changes in trend reliably with too few knots. The compromise adopted is to specify knots at six monthly intervals, but to retain only those which contribute significantly to the model.

There is a risk that the form of the trend may be exaggerated in the periods before the first knot and after the last knot. The reason is that the trend at time t is influenced most by adjacent data points, and for most t there are balanced sets before and after t. However, in the first sub-interval there are relatively few preceding points, and in the last sub-interval there are relatively few succeeding points. Thus, a short sequence of values in either sub-interval that are consistently either relatively high or relatively low could have an undue influence that they would not have elsewhere. The risk is reduced, but not eliminated, by having the first and last sub-intervals twelve months long, rather than six. Nonetheless, a sudden change in 1988, such as that shown in the KSI series in the upper part of figure 5, must be regarded as less reliable than the earlier changes: it is liable to be revised when full data for 1989 become available.

In the case of the first sub-interval, the complete solution is to start the analysis one or two years before the period of real interest, then discard this preliminary period. Clearly, no such solution is available with the last sub-interval, doubly unfortunate because it is the most recent trends that are of especial interest.

Observe that this fully-developed model includes the original model (1) as a special case, by setting

$$c_1 = d_1 = \ldots = d_{n-1} = 0$$

Thus, there is a nested family of models, extending from (1) to (5). It is possible to determine the optimal level of development appropriate for a particular time series using the criterion to be described in the next section. This yields the simplest model beyond which no further addition of variables will provide greater explanatory power. An important practical advantage of using this most parsimonious model is that the standard errors of its parameter estimates (in particular of a'') are lower for this model than for any models that include extra variables.

This has been presented as an automatic process, but the model can conveniently be re-fitted in a final stage to remove any short-term oscillations which are judged to be of marginal significance. The oscillations in 1985 in the KSI trend in the lower part of figure 1 are a case in point. The model could be re-fitted without the two 1985 knots: if the loss of fit were acceptably small and the new model was in other respects satisfactory, then a smoother trend would have been achieved at a statistically acceptable cost.

A.3 GOODNESS-OF-FIT

As with any linear regression model, the new family of models for casualty series is calibrated by finding the coefficients which minimise the sum:

$$SS = \Sigma_t (f'(t) - y_t)^2$$

where y_t is the value of the time series in month t. In measuring the 'goodness-of-fit' of a particular model, it is important to allow for the reduced degrees of freedom that result when extra variables (in particular, knots) are added. The appropriate measure is the Adjusted R^2:

$$\bar{R}^2 = 1 - \frac{(n-1)}{(n-p)} \cdot \frac{SS}{S_{yy}}$$

where n = number of data (ie the number of months),
p = number of variables

and $S_{yy} = \Sigma_t \, (y_t - (\Sigma_r y_r/n))^2$

As new variables are added, p increases and SS necessarily reduces, but it can be shown that $\bar{R}^2$ will increase only if the new variables have significantly increased the model's explanatory power. Thus, $\bar{R}^2$ provides the criterion by which to judge whether the original linear trend model is satisfactory, or by which to evaluate the contribution of extra knots. In the latter case, the technique of 'stepwise regression' is used to determine the simplest set of knots which will describe variations in trend adequately.

A.4 THE MINIMUM VALUE OF Q

The quotient

$$Q = \frac{\text{casualty trend during drink/drive hours}}{\text{casualty trend during rest of day}}$$

was introduced in section 3.1, and the question arose of the value to which Q might sink if drink/driving were to be eliminated. This section uses a simple model to assess Q′, the likely minimum value of Q. This is done first for car drivers and passengers, as suitable data exist for these groups. The results are then considered qualitatively to assess Q′ for other road users.

Consider car drivers first; for drivers of age a and sex s let:

$m(e,a,s)$ = mileage during evening (10 pm–4 am),
$m(d,a,s)$ = mileage during rest of day,
$c(e,a,s)$ = casualties per km travelled during evening,
$c(d,a,s)$ = casualties per km travelled during rest of day,

then

$$Q = \frac{\sum_{a,s} m(e,a,s).c(e,a,s)}{\sum_{a,s} m(d,a,s).c(d,a,s)}$$

This equation will now be applied to estimate Q′, so c(e,a,s) is the casualty rate in the evening that would be expected if drink/driving could be eliminated. Under these conditions, it is reasonable to assume that the casualty rate for evening travel will vary with age and sex in the same way as for travel during the rest of the day. The variation for the whole day has been quantified (Broughton, 1990), so the casualty rates can be re-written

$$c(e,a,s) = C(e) \; . \; c(a,s) \text{ and } c(d,a,s) = C(d) \; . \; c(a,s)$$

where c(a,s) is the known casualty rate calculated over the whole day and C(d) and C(e) represent the relative risks of travel during the two parts of the day. Also, let M be the total driver mileage and

$$m'(e,a,s) = m(e,a,s)/M \; , \; m'(d,a,s) = m(d,a,s)/M,$$

so

$$Q' = \frac{\Sigma\, m'(e,a,s).c(a,s)}{\Sigma\, m'(d,a,s),c(a,s)} \; . \; \frac{C(e)}{C(d)}$$

The first of these two quotients can be estimated using mileage data from the National Travel Survey and the known casualty rates; the value for car drivers is 0.077. When the calculation is repeated for car passengers, the value found is 0.089. Strictly, the NTS data refer to journeys started between 10 pm and 4 am, so mileage from journeys started earlier but not completed by 10 pm is excluded. It is partially offset in the calculation by mileage from journeys started before 4 am but not completed by then, but the actual values are likely to be slightly higher than these estimates.

The second quotient compares the accident risk in the two parts of the day. It cannot be estimated exactly, but factors such as fatigue and reduced visibility in the dark mean that it will certainly exceed 1.0, and could well be at least 1.5. Thus, Q′ is likely to exceed 0.10 both for car drivers and for car passengers.

When the first quotient is re-evaluated using fatality or KSI rates, its value changes very little. It is likely, however, that the second quotient will be higher for more serious injuries. At present, the proportion of casualties who are seriously injured is higher in the evening than in the rest of the day, as has been shown by the various figures comparing casualty quotients. The difference may reduce as the level of drink/driving falls, but it is unlikely to be eliminated. Consequently, the minimum value of Q is probably higher for severe casualties than for all casualties.

These examples show that the value of Q′ for a particular group of road users depends principally upon the proportion of road use that occurs in the evening and the ratio of the casualty rate in the evening to the rate in the rest of the day. For both motorcyclists and pedestrians, evening journeys probably constitute rather less of their total road use than is the case with car occupants. However, the ratio of casualty rates is probably higher than for car occupants, with the result that Q′ for these groups may well be similar to the values for car occupants, ie at least 0.10.

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